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Landsat Archive Conversion System (LACS)
Media Trade Study

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LACS Media Trade Study

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Preface

This document contains the Media Trade Study for the Landsat Archive Conversion System (LACS). The Trade Study presents the background, technical assessment, company stability assessment, test results, and the follow up recommendations as required by the Investigation & Technology Activity Lead.

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Abstract

This document is a trade study comparing offline digital archive storage technologies. The document compares and assesses several technologies and recommends which should be deployed for the LACS project and become the next generation standard for EDC. The EROS Data Center (EDC) must evolve to the next generation of digital archive technology and the technology chosen must remain viable for at least 15 years. The tape technologies assessed in this study include Quantum SuperDLT (SDLT), LTO Ultrium, and StorageTek (STK) 9940A/B. This study does not include technologies that have been deemed low performance due to insufficient capacity, transfer rate, dependability, or due to an unreliable recording method such as helical scan. For the purposes of this study, the extremely reliable 3480 and 3490 technologies are used as a benchmark.

Contents

1.0 Introduction

1.1 Purpose and Scope

This document provides an assessment of the options for the next generation of digital archive storage technology to be used for the LACS system at EDC.

The desire is to reduce current and future data migration costs by transcribing data from analog (instrumentation) media to digital (machine-readable) media, facilitating the automation of data ingest and transcription and realizing a cost savings approaching 90% for future transcriptions. By moving to digital media, robotic libraries may be used to store archived data and automate the conversion of media in the future.

1.2 Background

The United States Geological Survey (USGS), Earth Resources Observation Systems (EROS) Data Center (EDC), located in Sioux Falls, SD, currently archives offline datasets using several technologies. In 1992, the TMACS system was deployed to transcribe Landsat archives from HDT (High Density Tape) to DCT (Digital Cassette Tape). Both HDT and DCT utilize large, expensive analog instrumentation drives, which require frame synchronization, driving the cost of transcribing Landsat HDTs to DCTs to exceed $1,000,000 for each generation of media. Note that DCT and HDT are not purely analog. Although the data is stored in digital format, the crucial IRIG data is stored in analog format. Though much of the conversion from HDT has been completed, additional HDT tapes were recently received. All HDT tapes transcribed to DCT by TMACS have been retained since no backup copies of the DCT tapes have been made.

Locating, rehabilitating, and integrating HDT drives has been costly in terms of labor, parts, and vendor service costs. The ongoing maintenance costs for the HDT and DCT drives are excessive since there is little industry experience and only a single vendor to support each brand of drive. The HDT and DCT drives in existence today number in the dozens, with the count decreasing each year as other users transition to digital media.

The “technology of choice” for EDC archives has been the 35 GB DLT 7000 for the past three years. The WBVT and SPOT/STCS transcription systems were implemented in the past two years, transcribing HDT media to machine readable DLT 7000. The DLT 7000 drive was recently retired by Quantum, and although a DLT 8000 with special firmware would allow that drive to emulate the DLT 7000, it is not advisable to implement new systems with the discontinued DLT 7000, or the somewhat orphan DLT 8000. A recent EDC study of DLT 7000 errors revealed that they exhibit a greater percentage of data loss as compared to 3480, 3490 and 9840.

Table 1-1 summarizes the offline archive tape technologies currently in use at EDC:

Tape Drive Technology	Capacity	Transfer rate	Type
HDT	3.4 GB	10.6 MB/sec	Analog
3480	200 MB	3 MB/sec	Digital
3490	900 MB	5 MB/sec	Digital
DLT 7000	32 GB	4 MB/sec	Digital
DCT (Ampex DCRsI)	45 GB	12 MB/sec	Analog

Table 1-1 Past and current archive technologies used at EDC

HDT, 3480/3490, and DCT have proven to be robust and high-performance for their time. As technology advances, as datasets grow, as media ages, and as Digital Library space fills, EDC must migrate data to newer, more physically compact, and higher performing storage technologies. The LACS system will replace TMACS in 2002. LACS will have the ability to convert analog HDT and DCT tapes to a digital technology that will not require expensive DCT drives, frame synchronizers, and media. The archive technology to be used by LACS will be determined by this study.

2.0 Technical Assessment

2.1 Evaluation Criteria

Since the foremost goal of the LACS (and similar transcription projects) is data preservation, the primary criteria for the selection of the drive technology must be reliability. Several elements contribute to data reliability:

- The use of a master copy. The dependence on the master copy, and the level of risk rise when the working copy is not robust. Any of the technologies would require a master copy though some would rely on it more. Note that the master and working copies need not be on similar media, though generation and recovery of a working copy is simplified if the storage capacities are the same. The existence of a master copy is a constant for all of the technologies since the use of master copy is mandatory.

- The storage location and environment. This is a constant for all of the technologies assessed since any would be stored in a safe environment.

- The composition of the media. Some media compositions last much longer than others. This too is a constant since all of the assessed technologies use the same long-life metal particle technology.

- Tape handling within the drive. This characteristic defines how a tape is handled by the drive: whether contact is made with the recording surface, how many passes are required to read or write an entire tape, and the complexity of the tape path.

- Error handling. The ideal drive minimizes data loss through CRC or other data recovery methods, and allows data to be read after skipping over an error. Though error detection upon write is required, additional attention to data recovery upon read is a higher priority.

- Suitability for archiving (the target market and design philosophy of the drive). This criterion is subjective as it is the perceived importance that the manufacturer placed on data retention. For example, a drive targeted to backups would be designed for write many, read rarely – and errors would typically be detected upon write. Backup drives are typically built for speed and low cost, with robustness a secondary factor. A drive targeted to archival would be designed for write once, read many – and errors would typically be detected upon read. Archival drives are typically built for robustness, with speed and cost a secondary factor. Both backup and archival drives attempt error detection and recovery upon both read and write, but an archival drive typically places more importance on data recovery on read since data may no longer be available – while a backup drive places more importance on write error detection since the data is still available and can be easily rewritten.

Following data preservation, the remaining criteria are much less important. These include transfer rate, capacity, cost, and vendor financial stability.

2.2 Reliability

The reliability of a long-term archive technology relates primarily to the long-term viability of the recorded media. Since it is wise to implement a technology early enough in it's life cycle that drives can be kept viable through the expected 15 year generation cycle, a definitive leader in reliability is difficult to determine. This study bases the reliability assessment on past experience with the vendor and their products, on specifications, and on the experiences gained from benchmarking or from others experiences (ECS).

Based on a recent EDC study of DLT 7000 errors, it has been determined that the way that Quantum implemented serpentine recording leads to an increase in data loss upon each occurrence, as compared to 3490. When an error occurred, it frequently appeared in several places on the tape (presumably in the same

linear location, across multiple tracks) and there was more data loss at a given location as compared to 3490. In many cases, data could not be recovered past the error, as is typically possible with 3490. It appears that SDLT simply increases the density and the number of serpentine passes as compared to DLT 7000, so it can be deduced that SDLT would suffer from the same data loss as DLT 7000. LTO also utilizes serpentine recording, though their error handling may be different.

STK 9940A uses serpentine recording but uses many fewer passes than either LTO or SDLT. In addition, 9940 drives do not touch the recording surface. Past history with STK has shown that they put reliability of data before performance or cost. It is not clear that this is true of either SDLT or LTO, since they target their drives for the high-volume low-margin backup market, which emphasizes cost, transfer rate, and capacity, but not necessarily long-term retention of recorded data. On two occasions at EDC, 9840 tapes which encountered unrecoverable errors were sent to STK for recovery (at no charge). One tape was recovered, but the other was unrecoverable due to cartridge contamination. Further, STK's emphasis on and success in write-few/read-many nearline technology is evidence of their data retention mindset. The 9940 drives work well in either a write-few/read-many or write-once/read-many scenario.

Technology	Serpentine passes	Target Market	Usage pattern	Errors expected	Recovery method for target market
STK 9940A	18	Archival	Write once, read many	On read	Copy from master
STK 9940B	TBD	Archival	Write once, read many	On read	Copy from master
Seagate LTO Ultrium	48	Backup	Write many, read rarely	On write	Discard media, re-run
Quantum SuperDLT	56	Backup	Write many, read rarely	On write	Discard media, re-run

Table 2-1 Design criteria and target market

2.3 Transfer Rate

Transfer rate is important since it dictates how many months or years will be required to transcribe an archive. Since the maximum transfer rate of the DCT drive is 12 MB/sec, the transfer rate of the output drive should be as close to that as possible although LACS has no stated requirement for the transfer rate of the output drive. Of the currently available drives, only LTO would meet the goal. The 9940B would far exceed the goal.

Tape Drive Technology	Write Transfer Rate	Read Transfer rate
STK 9940B	20 MB/sec	20 MB/sec
Seagate LTO Ultrium	14.66 MB/sec	10.32 MB/sec
Quantum SuperDLT	8.12 MB/sec	6.35 MB/sec
STK 9940A	9.51 MB/sec	9.95 MB/sec

Table 2-2 Measured transfer rates
(Shaded entries have been benchmarked)

2.4 Capacity

There is no specific LACS requirement for capacity but the strategy is to conserve archive space by increasing per media capacity. The current archive media of choice at EDC is DLT 7000 at 32 GB per tape. It would be advisable to at least double the current capacity, which would be 64 GB. The 9940A would achieve 88% of this capacity, with all of the remaining drives exceeding 64GB.

Tape Drive Technology	Capacity
STK 9940B	200 GB
Quantum SuperDLT	98.83 GB
Seagate LTO Ultrium	97.75 GB
STK 9940A	56.65 GB

Table 2-3 Measured capacities
(Shaded entries have been benchmarked)

2.5 Analysis

LTO:

- [The Seagate LTO has the highest transfer rate of the currently available drives.
- [LTO has an on-board chip, which stores information such as errors.
- [LTO drives are currently the lowest cost drive. LTO drives are 93% of the cost of SuperDLT and 15% of the cost of 9940A.
- , LTO is targeted to the backup market where speed, capacity, and cost are more important than long-term viability of the data. Since backups tapes are write-many/read-rarely, errors would likely show up in a write pass where they can be worked around (rewrites) or the media discarded. The retention of backup tapes is typically measured in days, weeks, and months rather than years or decades.
- , LTO uses serpentine recording (though they do not call it that) and may suffer from the same data loss characteristics as the DLT 7000. Reliability is a concern since the serpentine nature of LTO would mean that one end-to-end read/write would incur 48 passes.
- , LTO was co-developed by Seagate, IBM, and HP. This type of deployment makes it possible for each vendor to interpret the specifications differently, and to design drives which may have incompatibilities. Though they may test interoperability, competition encourages differentiation. This problem is often seen in the networking marketplace – a new standard comes out, and vendors constantly struggle with incompatibilities. Because of this concern, if LTO were selected it would be advisable to utilize only one vendor.
- , Repair would require a return to the vendor service center. Due the typical downtime associated with this method of service, spare drives would be required.
- , There is very little EDC or industry experience with LTO since it is new. EDC recently procured a drive and has been testing. During the initial tests, the LTO performed very close to the specified speed and capacity. An unrecoverable error did occur, and data could not be recovered past the error.
- • The second, third, and fourth generations of LTO Ultrium have been projected but not scheduled. The next three generations will have uncompressed capacities of 200/400/800 GB and uncompressed transfer rates of 32/64/128 MB/sec.

SDLT:

- [SDLT has the highest non-compressed capacity at 98.83 GB (though well under the rated capacity of 100 GB and only slightly higher than LTO).
- [SDLT drives are priced 6% higher than LTO, but still reasonably priced at 16% of the cost of 9940A.

, SDLT is targeted to the backup market where speed, capacity, and cost are more important than long-term viability of the data. Since backups tapes are write-many/read-rarely, errors would likely show up in a write pass where they can be worked around (rewrites) or the media discarded. The retention of backup tapes is typically measured in days, weeks, and months rather than years or decades.

, There is little EDC experience with SDLT. EDC recently procured a drive and has been testing. During the initial tests, the SDLT performed poorly – not coming close to the specified speed and capacity.

, Since the design is basically a higher density DLT 7000, SDLT will likely suffer from the same data loss characteristics as the DLT 7000.

, Reliability is a concern since the serpentine nature of SDLT would mean that one end-to-end read/write would incur 56 passes.

, Repair would require a return to the vendor service center. Due the typical downtime associated with this method of service, spare drives would be required.

• Though SDLT will be available from multiple vendors, if SDLT is chosen it is advised that EDC choose Quantum brand drives.

STK 9940:

[9940 should have the highest reliability based on past experience with both STK and 3490 and since it uses 'wider' tracks to reduce serpentine passes and nothing touches the recording surface. Since fewer passes are used (as compared to SDLT and LTO) the implementation has proven more robust.

[An on-site STK maintenance contract is already in place. No spare drives would be required if downtimes less than one day are acceptable.

[STK drives have proven more robust in design than Quantum DLT 2000/4000/7000 drives.

[9940 is targeted to the long-term archive market where data viability is more important than speed, capacity, or cost. Since archive tapes are write-once/read-few, errors would likely show up in a read pass where data would be lost unless recovered from the master copy. The retention of archive tapes is typically measured in years or decades, rather than days, weeks, or months.

[The 9940 drives are compatible with the EDC STK silos. This would preserve the investment should plans proceed to move towards a nearline working archive.

[The 9940 is a follow on product to the very reliable 3490 and 9840.

[The 9940 has proven reliable for ECS, much more than D3.

[Although Quantum and the LTO consortium have hinted at future high-density drives, it would appear that 9940B would be the market leader when it ships and STK expects to enjoy this advantage for a year.

[The shelving and tape carriers currently used for 3480/3490 would work with 9940.

, The issue of a single vendor is mostly moot since we would stick with a single vendor for LTO or SDLT. The only reason that this would be a disadvantage of going with STK would be in the case of bankruptcy – but it would be more likely that they would be bought out than fold.

, The 9940 drives are much more expensive than LTO or SuperDLT, although the total project price with media is much lower for 9940B due to data density.

, Expensive ($7k) racks are required in order to utilize the 9940 drives outside of the Silo environment for which they were designed.

, The second generation of 9940, the 9940B, will ship in May or June of 2002. The transfer rate and capacity will increase dramatically, and since the same media is used, the cost per terabyte will decrease dramatically. The 9940C is due to ship in 2003 and will double the capacity and transfer rate of the 9940B, but will use different media. The 9940A to 9940B, and the 9940B to 9940C upgrades would involve a trade-in rather than a field modification.

2.6 Technical Summary

- Of the currently shipping technologies, LTO has the highest transfer rate, followed by 9940A, and lastly SDLT. The 9940B technology will be 36% faster than LTO, 100% faster than 9940A, and 146% faster than SDLT.

- Of the currently shipping technologies, SDLT has the highest non-compressed capacity, followed very closely by LTO, and then 9940A. The 9940B technology will have a capacity 102% higher than SDLT, 104% higher than LTO, and 253% higher than 9940A.

- The 9940 drives which are based on 9840 technology and are descendants of 3490 technology have a fine heritage. The 3490 and 9840 technologies have proven robust at EDC and at other sites. The 9940A has proven robust in the few months they have been in use by ECS.

- The design of the 9940 is targeted to nearline and archival storage while SDLT and LTO are targeted to the lucrative backup drive market. While this market targeting is not absolute, it does affect the suitability of the drives for archival purposes.

3.0 Vendor Financial Stability

3.1 Overview

This section is intended to provide a subjective analysis of the stability of each of the three vendors.

3.2 StorageTek

- STK came back from the brink of bankruptcy, after filing chapter 11 several years ago. Though they have excellent technology, their prices are high and their target market limited.

- STK has responded to pressure from competing technologies such as DLT, SDLT, and LTO, by becoming a reseller of those technologies. STK positions those competing technologies for low-end, backup storage requirements in smaller robotic libraries while positioning the 9840 and 9940 for near-line and archival or enterprise storage in the large robotic libraries. STK has also become a reseller of nearline software, and disk technologies in order to become a one-stop-shop.

- The five year stock price trend is fairly level, though it has risen over the past year when most other technology stocks have dropped. STK streamlined and downsized last year, prior to most other technology companies, anticipating the tougher times. Stock is listed as a 'hold'. Recent data: http://cnnfn.cnn.com/MGI/snap/8405N.htm

3.3 Quantum

- Quantum, once primarily a disk drive manufacturer, bought the DLT technology from Digital Equipment Corporation (now Compaq) and has evolved DLT through several successive generations. Each generation has become faster, denser, and more robust. DLT has been a successful product for them.

- Quantum responded to 'sole-source' criticism by licensing DLT to two other firms. Quantum and Tandberg recently announced that Tandberg has been granted a license to produce the SDLT.

- Quantum recently sold their disk drive division to rival Maxtor. Quantum will now concentrate on enterprise storage (NAS/SAN) and SDLT. Quantum recently announced that it would not proceed with the $100M IPO of its Snap Appliances unit, which provides network-attached storage, because of market conditions.

- The five-year stock price trend is upward. Stock is listed as a 'hold'. Quantum joined the Dow two years ago, moving from the Nasdaq. Recent data: http://cnnfn.cnn.com/MGI/snap/A1F93.htm

3.4 Seagate/IBM/HP

- IBM is solid is a rock, though they could drop LTO if it does not prove lucrative. Stock is listed as a 'buy'. Recent data: http://cnnfn.cnn.com/MGI/snap/4741N.htm

- HP has been a solid company, though they have gone through their ups-and-downs and have adjusted. Like IBM, they would drop LTO if it does not prove lucrative. Stock is listed as a 'hold'. Recent data: http://cnnfn.cnn.com/MGI/snap/4302N.htm

- Seagate is the smallest of the three companies but they are quite solid. They have the best drive of the three LTO vendors (currently) so they are probably least likely to bail out on LTO. The five-year stock price trend is upward. They are currently listed as a 'hold'. Recent data: http://money.iwon.com/ht/rs/fin/es/s/seg.html

4.0 Conclusions and Recommendations

4.1 Overview

The purpose of this section is to advise what the LACS offline archive technology should be.

4.2 Total project cost

The total project costs for four drives and two copies of the archive (total of 320 TB) are shown in the following table:

Technology	Drive $/ea	Media $/TB	Total LACS cost
STK fiber-channel 9940B	$39,500	$400	*$286,000
Quantum SuperDLT	$4,850	$1,202	$404,040
Seagate LTO Ultrium	$4,542	$1,163	$390,328
STK 9940A	$29,000	$1,379	*$557,280

Table 4-1 Projected LACS cost

*Total price includes two standalone racks that are required
Spare SDLT and LTO drives required but not included in the total

4.3 Weighted Decision Matrix

The following table provides a weighted analysis of the four drives. This weighting emphasizes the importance of traits contributing to data preservation. Note that for the 9940B, the ratings were based on 9940A ratings and then adjusted for the projected specifications.

#	Selecton Criteria	RW0	Relative weight	LTO	Super DLT	9940A	9940B	LTO	Super DLT	9940A	9940B
1	*Reliability of media	H	10	7	7	10	10	70	70	100	100
2	*Suitability for archival	H	9	7	7	10	10	63	63	90	90
3	*Customer Comfort	H	8	6	6	9	8	48	48	72	64
4	*Transfer rate	M	7	9	5	7	10	63	35	49	70
5	Capacity	M	7	9	9	8	10	63	63	56	70
6	Media cost per TB	M	6	7	6	6	10	42	36	36	60
7	Drive cost	M	6	10	10	5	5	60	60	30	30
8	Maintenance Cost	M	6	10	9	7	7	60	54	42	42
9	Vendor Financial Stability	L	5	9	9	8	8	45	45	40	40
	Total Weighted Score							**514**	**474**	**515**	**566**
	* = Required Items RW 0 = Relative Weight -- High/Med/Low RW# = Relative Weight from 1-10, 10 being highest										

Table 4-2 Decision matrix

4.4 Conclusions

From table 4-2 above, the clear choice is 9940B though it is a speculative rating and will not ship until late spring of 2002. The 9940A rated high but since the 9940B will ship in an acceptable timeframe and will only cost slightly more, it would not make sense to go with 9940A. LTO made a very favorable showing, and having a master copy would reduce data loss risk – but it would not be as safe as 9940. The primary criteria is reliability and there is a clear comfort factor with 9940 technology since it is descended from the venerable 3490 and has been performing very well for ECS. The 9940 is based on 9840 technology, which has proven very robust at EDC.

Note that the LTO and SDLT are not being entirely dismissed as archive devices. With adequate master copies, they may be viable for some datasets. For this reason, one of each drive has been procured. With testing completed, the drives will likely be used for archival of a less critical dataset. This archive may utilize one copy on LTO and one on SuperDLT.

4.5 Recommendations

It is recommended that LACS procure four Fiber-channel STK 9940B drives when they become orderable early in calendar year 2002. Fiber channel would be used in order to avoid buying a fifth drive and to allow drive sharing between the three systems. Ingest would be delayed until the 9940B drives are delivered in June. MDA could use any drive to test the requested changes since the NLAPS modifications specify support of a generic tape drive (no tie to specific capacity or speed). It is also recommended that the LTO drive be used for LACS testing at EDC prior to installation of the 9940B drives. If production must proceed prior to the availability of the 9940B, an interim deployment with LTO is possible – although this would lead to a 'conversion within a conversion' and should be avoided.

Item	Price ea.	Qty	Total
9940B drive	$ 39,500.00	4	$ 158,000.00
9940B rack	$ 7,000.00	2	$ 14,000.00
8-port Fiber hub	$ 10,000.00	1	$ 10,000.00
Fiber HBA interfaces	$ 2,000.00	3	$ 6,000.00
Copper FC cables	$ 500.00	5	$ 2,500.00
		Total	**$ 190,500.00**

Table 4-3 Hardware cost

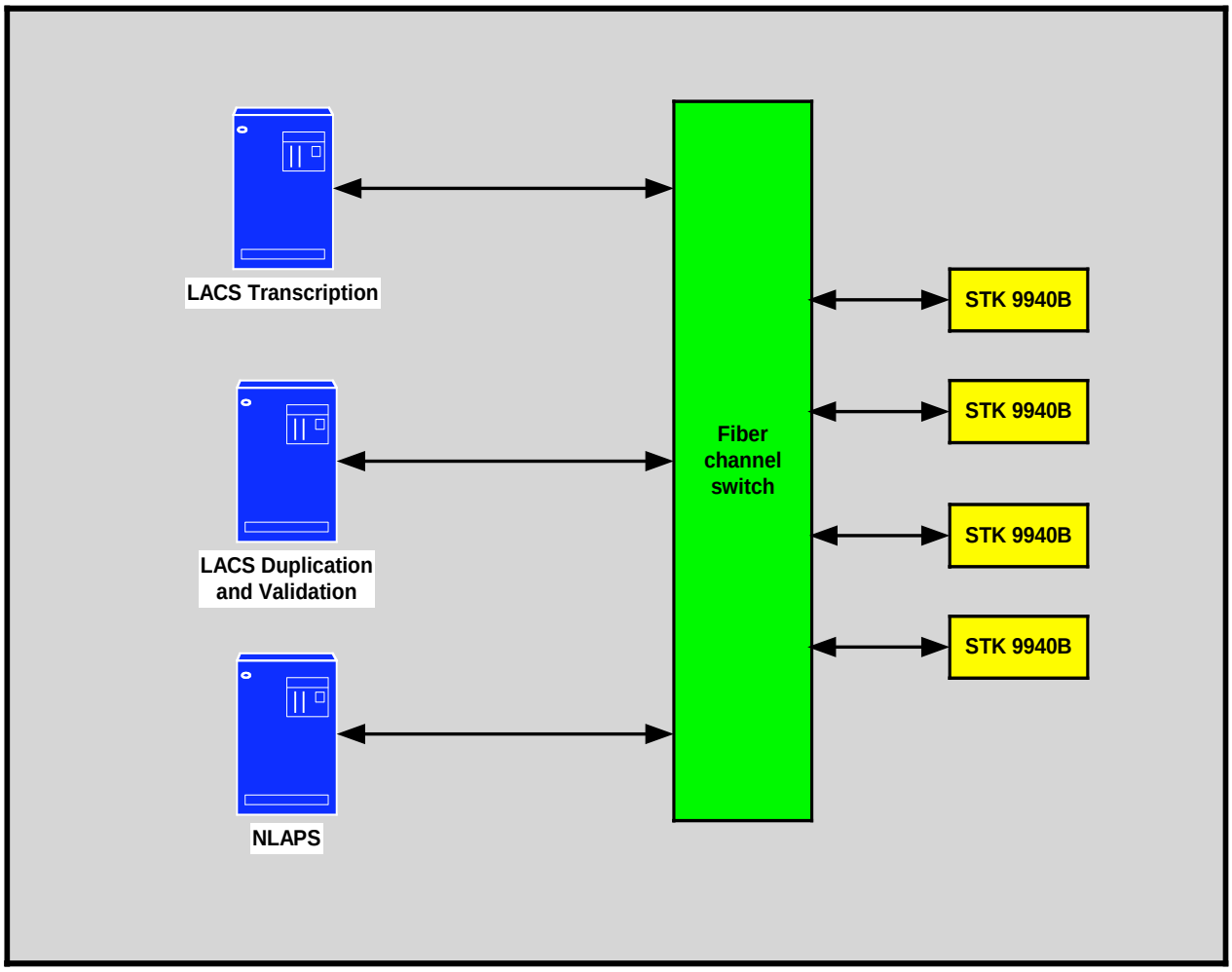

Diagram 4-1 System Diagram

Abbreviations and Acronyms

CCT	Computer Compatible Tape
CRC	Cyclic Redundancy Check
DCT	Digital Cassette tape
DLT	Digital Linear Tape
ECS	EOS (Earth Orbiting System) Core System
GB	Gigabytes
HDT	High Density Tape
HP	Hewlett Packard
IBM	International Business Machines
IPO	Initial Public Offering
IRIG	InteRange Instrumentation Group (timecode format)
LACS	Landsat Archive Conversion System
LTO	Linear Tape Open
MDA	Macdonald Dettwiler and Associates
NAS	Network Attached Storage
NLAPS	National Landsat Archive Production System
SAN	Storage Area Network
SDLT	Super DLT
SPOT	Systeme pour l'Observation de la Terre
STCS	SPOT/TMR Conversion System
STK	StorageTek
TB	Terabytes
TBD	To Be Determined
TMACS	TMMSS Archive Conversion System
WBVT	Wide Band Video Tape